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TITLE: Method and apparatus for measuring the Young's modulus of thin film by generating electrostatic force to make microstructure deform

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INT-CL (IPC): G01L001/00

ABSTRACTED-PUB-NO: TW 457366A

BASIC-ABSTRACT: NOVELTY - The present invention provides a method for measuring the Young's modulus of thin film and its apparatus, in which a microstructure manufactured by a semiconductor process is used to measure the Young's modulus.

DETAILED DESCRIPTION - This microstructure is fabricated on a substrate and includes the followings: the first electrode, which is located on the substrate; the fixed terminal, which is separated from the first electrode; the second electrode, which is floated on the substrate and is

on top of the first electrode; and the floating thin film layer, which is bridge connected with the second electrode and the fixed terminal. The floating thin film layer includes the thin film material that is to be measured the Young's modulus. By applying different voltages to the first electrode and the second electrode, electrostatic force is generated for both the first electrode and the second electrode such that they are attracted by each other and the second electrode is made to close to the first electrode. In addition, the floating thin film layer is then brought to deform. Through the electrostatic force and the quantity of deformation, the Young's modulus can be calculated.

ADVANTAGE - Young's modulus is measured conveniently and cheaply.

CHOSEN-DRAWING: Dwg.1/1

TITLE-TERMS:

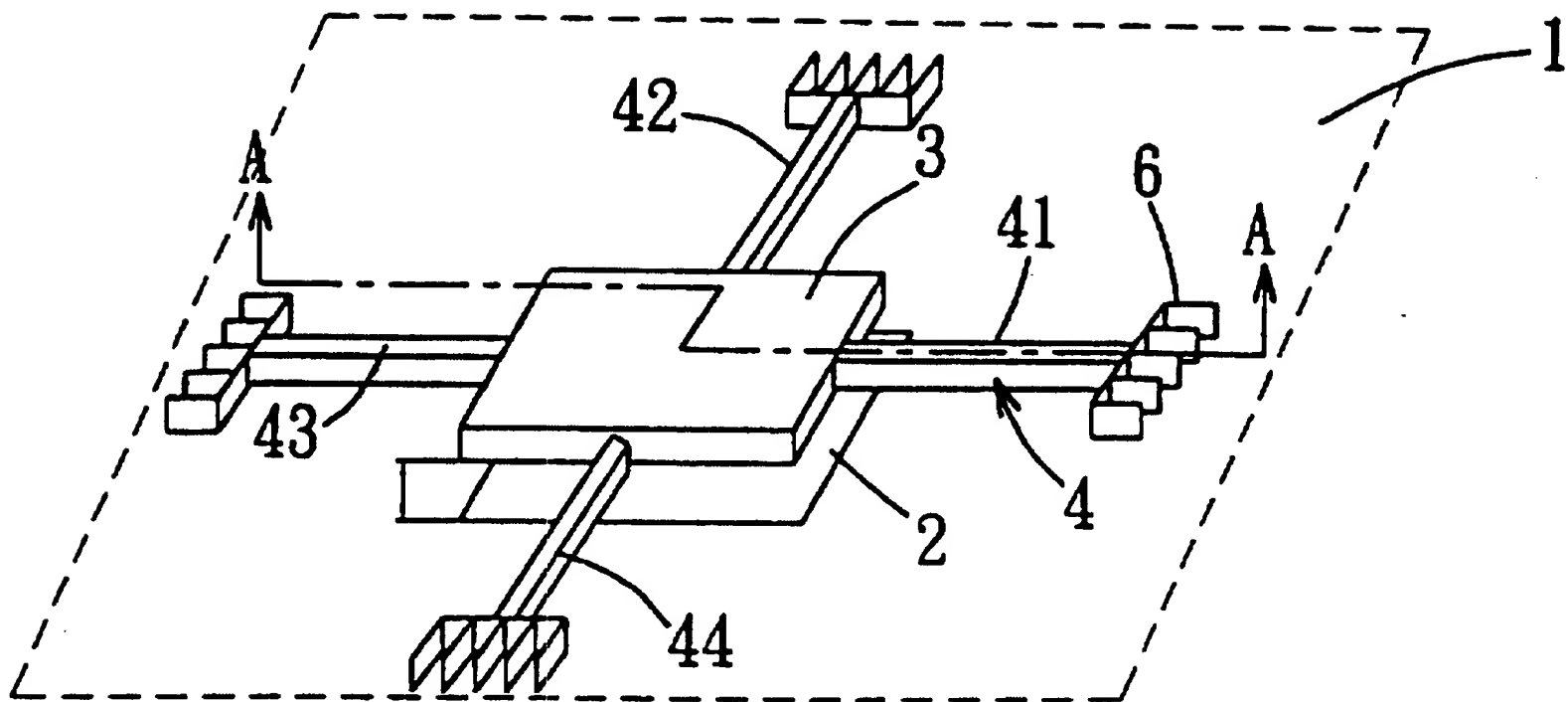
METHOD APPARATUS MEASURE YOUNG MODULUS THIN FILM GENERATE
ELECTROSTATIC FORCE
MICROSTRUCTURE DEFORM

DERWENT-CLASS: S02 U11

EPI-CODES: S02-A02D; S02-J10; U11-F01;

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Chinese Patent

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A Method and Apparatus for Measuring

Young's Coefficient of Thin Films

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UNITED STATES PATENT AND TRADEMARK OFFICE

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Measuring Young's Coefficient of
Thin Films

**A Method and Apparatus for Measuring
Young's Coefficient of Thin Films**

[57] What Is Claimed Is:

1. A method for measuring Young's coefficient of thin films, which employs a micro mechanism to measure Young's coefficient. This micro mechanism is made of semiconductors consisting of a semi-insulated substrate, first electrode formed on the substrate, fixed ends located on at least two sides of the first electrode and fixed on the substrate, a suspended second electrode located above the first electrode, and a suspended thin film layer bridging the fixed ends and the second electrode. The suspended thin film layer consists of thin films made of materials with which the Young's coefficient is to be measured. The measurement method includes the following steps:

a. Apply different voltages on the first electrode and the second electrode, causing the second electrode to come close to the first electrode due to the attraction of electrostatic force. The applied external force drives the suspended thin film layer to shift and deform.

b. Obtain the Young's coefficient of the suspended thin film layer based on the external force and deformation of the suspended thin film layer.

2. A method of measuring Young's coefficient of thin films according to Claim 1 wherein a DC power source is respectively connected to the first electrode and the second electrode as

¹ Numbers in the margin indicate pagination in the foreign text.

described in step a in order to provide the first electrode and the second electrode with different voltage values.

3. A method of measuring Young's coefficient of thin films according to Claim 2 wherein the positive pole of the DC power source is electrically connected to the second electrode while the negative pole of the DC power source is electrically connected to the first electrode.

4. A method of measuring Young's coefficient of thin films according to Claim 3 wherein a galvanometer and a resistance are connected in series to the positive pole of the DC power source as described in step b. When the DC power source applies voltages on the electrodes, the galvanometer can measure the electric current as a non-zero value. When the DC power source increases the supplied voltage to a given value that causes the electrodes to contact, the galvanometer measures the change of electric current as 0. As such, the given voltage value is obtained for further calculation of electrostatic force.

5. A method of measuring Young's coefficient of thin films according to Claim 1 wherein the external force as described in step b has something to do with the electrostatic force and the weight of the second electrode.

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6. A method of measuring Young's coefficient of thin films according to Claim 1 wherein the micro mechanism is formed through the following steps:

C-1. Prepare a substrate made of the semi-conductor material;

C-2. Form the first electrode on the substrate;

C-3. Deposit a sacrifice layer on the substrate;

C-4 Deposit the second electrode and suspended thin film layer on the sacrifice layer, and form fixed ends on the

substrate. The suspended thin film is located between and connects the fixed ends and the second electrode;

C-5. Remove the sacrifice layer so that the second electrode and the suspended thin film are supported by the fixed ends and are suspended on the substrate.

7. A method of measuring Young's coefficient of thin films according to Claim 6 wherein steps C-1 through C-4 can be executed by way of CMOS standard procedure.

8. A method of measuring Young's coefficient of thin films according to Claim 6 wherein the first electrode contains at least one metal layer.

9. A method of measuring Young's coefficient of thin films according to Claim 8 wherein the material of the metal layer is aluminum.

10. A method of measuring Young's coefficient of thin films according to Claim 6 wherein the sacrifice layer is a dielectric layer made of dielectric material.

11. A method of measuring Young's coefficient of thin films according to Claim 10 wherein the sacrifice layer is composed of silicon dioxide (Si_2O).

12. A method of measuring Young's coefficient of thin films according to Claim 6 wherein each fixed end contains at least one metal layer.

13. A method of measuring Young's coefficient of thin films according to Claim 6 wherein the first electrode formed in step C-2 is in rectangular shape.

14. A method of measuring Young's coefficient of thin films according to Claim 13 wherein there are four fixed ends as described in step C-4 that are located on four sides of the first electrode, respectively.

15. A method of measuring Young's coefficient of thin films according to Claim 14 wherein each fixed end is in comb structure.

16. A method of measuring Young's coefficient of thin films according to Claim 14 wherein the suspended thin film layer as described in step C-4 consists of four girds. Each gird connects the corresponding fixed end and the side of the second electrode.

17. A method of measuring Young's coefficient of thin films according to Claim 6 wherein the suspended thin film layer contains at least one metal layer in order to connect the fixed end to the first electrode, with which voltage can be applied to the second electrode through this fixed end.

18. A method of measuring Young's coefficient of thin films according to Claim 6 wherein the suspended thin film layer contains at least one metal layer and at least one layer consisting of the material with which the Young's coefficient is to be measured if the said thin film material is non-metallic material, and the Young's coefficient of the thin film to be measured is solved through cross-section area conversion method as described in step b.

19. A method of measuring Young's coefficient of thin films according to Claim 18 wherein the thin film material to be measured is silicon dioxide.

20. A method of measuring Young's coefficient of thin films according to Claim 18 wherein the thin film material to be measured is silicon nitride.

21. A method of measuring Young's coefficient of thin films according to Claim 6 wherein etching technique is used in step C-5 to remove the said sacrifice layer.

22. A method of measuring Young's coefficient of thin films according to Claim 21 wherein the said etching technique features wet etching.

23. A method of measuring Young's coefficient of thin films according to Claim 21 wherein, the said etching technique features dry etching.

24. An apparatus of measuring Young's coefficient of thin films, including:

A micro mechanism formed on a substrate. The micro mechanism consists of the first electrode located on the substrate, fixed ends on at least two sides of the first electrode, a suspended second electrode on the first electrode and a suspended thin film layer connecting the said fixed ends and the second electrode. The suspended thin film layer contains the thin film with which the Young's coefficient is to be measured.

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A DC power source with one end electrically connected to the first electrode while the other end electrically connected to the second electrode.

When the DC power source provides electric voltage, electrostatic force is produced due to the voltage difference between the first electrode and the second electrode. The electrostatic force attracts the said first electrode to approach the said second electrode, thus applying external force to deform the suspended thin film layer. The external force and the deformation are used to derive the Young's coefficient of the suspended thin film layer.

25. An apparatus of measuring Young's coefficient of thin films according to Claim 24, which includes a serially connected galvanometer and a resistance. The galvanometer is electrically

connected to the DC power source and the end of the second electrode. As such, when the DC power source outputs voltage, the galvanometer measures a non-zero voltage. When the voltage output from the DC power source increases to a given voltage, the second electrode is in contact with the first electrode, resulting in short circuit and zero value of electric current measured on the galvanometer. Thus, the given voltage value is determined.

26. An apparatus of measuring Young's coefficient of thin films according to Claim 24 wherein the first and second electrodes are made of metal material.

27. An apparatus of measuring Young's coefficient of thin films according to Claim 26 wherein the metal material is aluminum.

28. An apparatus of measuring Young's coefficient of thin films according to Claim 24 wherein the second electrode is in rectangular shape.

29. An apparatus of measuring Young's coefficient of thin films according to Claim 28 wherein the said fixed ends are four fixed ends located on four sides of the second electrode respectively.

30. An apparatus of measuring Young's coefficient of thin films according to Claim 29 wherein the suspended thin film layer consists of four girds connecting the corresponding fixed ends and the said second electrode.

31. An apparatus of measuring Young's coefficient of thin films according to Claim 24 wherein the material of the fixed ends is metal.

32. An apparatus of measuring Young's coefficient of thin films according to Claim 31 wherein the suspended thin film layer includes at least one metal layer. The DC power source

provides the second electrode with voltage via the fixed end and the suspended thin film layer.

33. An apparatus of measuring Young's coefficient of thin films according to Claim 32 wherein the materials of the fixed ends and the metal layer of the suspended thin film layer are aluminum.

34. An apparatus of measuring Young's coefficient of thin films according to Claim 24 wherein the fixed ends are in comb structure.

Brief Illustration of Drawings:

Fig. 1 is a partial, three-dimensional illustration of the first good example of the invention.

Fig. 2 is a cross-sectional diagram of the pre-fabricated first good example of the invention.

Fig. 3 is a cross-sectional diagram of the first good example of the invention.

Fig. 4 is a diagram of the first good example of the invention where voltage is not applied in the measurement.

Fig. 5 is a diagram of electric circuit of Fig. 4.

Fig. 6 is a diagram of the first good example of the invention where voltage is properly applied in the measurement.

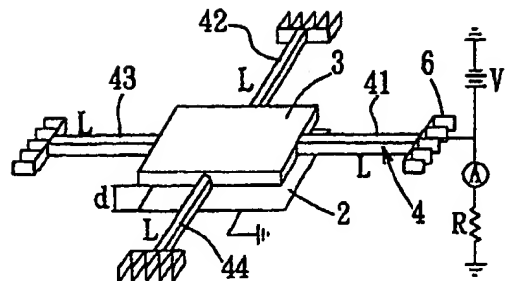
Fig. 7 is a diagram of electric circuit of Fig. 6.

Fig. 8 is a cross-sectional diagram of the second good example of the invention.

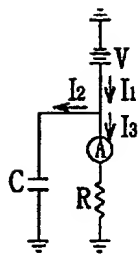
Fig. 9 is a cross-sectional diagram of the second good example of the invention.

A cross-sectional view of a semiconductor device. A central raised region (3) contains a stack of layers: P1 (polysilicon), M4 (metal), D3 (dielectric), M3 (metal), and M2 (metal). This central region is flanked by two side regions (5 and 41) which contain a stack of layers: M1 (metal), D2 (dielectric), and M2 (metal). The entire structure is on a substrate (1) with a base layer (2). The top surface is labeled 6, and the bottom surface is labeled 6. The central region is also labeled 3, and the side regions are labeled 5 and 41.

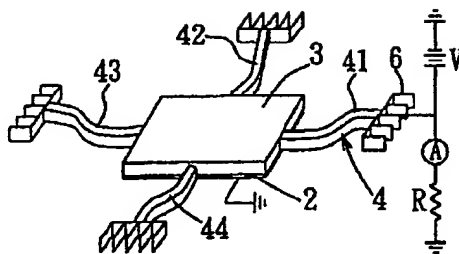
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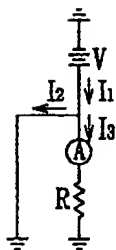
第四圖



第五圖



第六圖



第七圖

KEY:

Fig. 4

Fig. 5 ... Fig. 6

Fig. 7

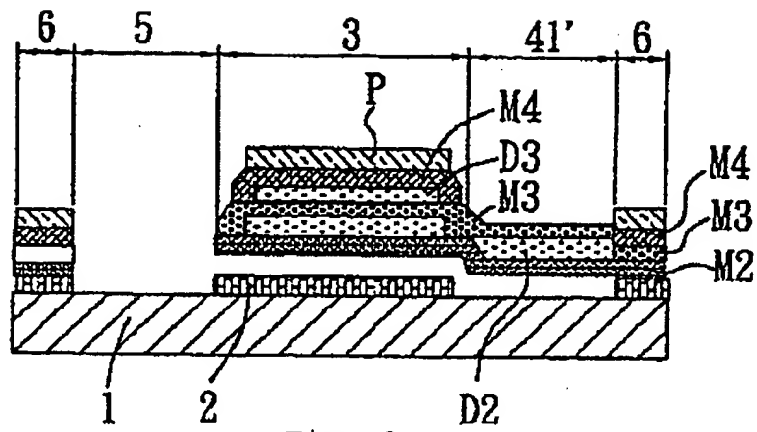


Fig. 8

第八圖

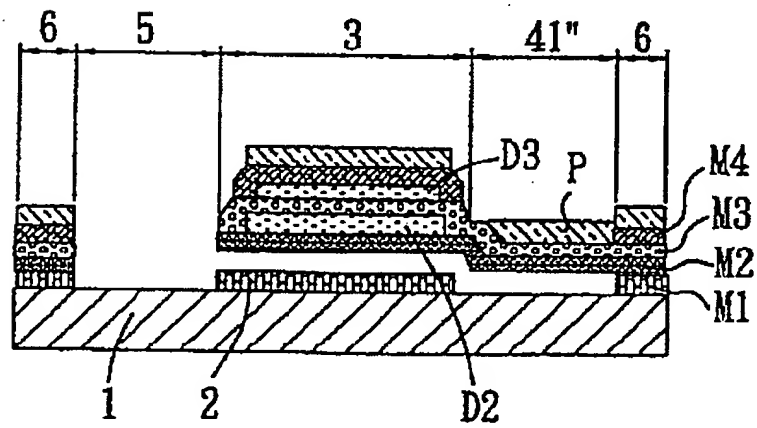


Fig. 9

第九圖